

CLAIMS

What is claimed is:

1. A tube expander spindle assembly, comprising:

a plurality of bladder assemblies, each bladder assembly having an axial first end and an axial second end, each end having a means for attachment, and an expandable bladder positioned between the first end and the second end in fluid communication with the first end and second end;

a first connection tube of preselected length having a first end and a second end with a means for locating the first connector tube relative to a datum mounted to the first end, and means for attachment at the second end for removably attaching the first connection tube to an axial end of one of the bladder assemblies, the connection tube further including an axially extending aperture in fluid communication with the bladder assembly;

a plurality of additional connection tubes of preselected length, each tube having a two axially-opposed end, with a means for connection at each end for attaching one end of the connection tube to an axial end of one of the bladder assemblies of the plurality of bladder assemblies and the remaining end to an axial end of another of the bladder assemblies of the plurality of bladder assemblies, each of the plurality of the connection tubes further including an axially extending aperture to provide fluid communication between the attached the bladder assemblies; and

means for fluidly sealing a second end of the last bladder of the plurality of bladder assemblies.

2. The expander spindle assembly of claim 1 wherein the means for locating the first connector tube is a hard stop.

3. The expander spindle assembly of claim 1 further including means for fluidly sealing the means for attachment at the second end of the first connection tube and the axial end of the bladder assembly, and between the means for connection at the end of the plurality of connection tubes and the means for attachment at each end of the plurality of bladder assemblies.
4. The expander spindle assembly of claim 1 further including a fluid and means for pressurizing fluid in the expander assembly.
5. The expander spindle assembly of claim 4 wherein the means for pressurizing the fluid includes a pump.
6. The expander spindle assembly of claim 5 wherein the pump is a pneumatic pump and the fluid is a compressible gas.
7. The expander spindle assembly of claim 5 wherein the pump is a hydraulic pump and the fluid is a hydraulic fluid.
8. The expander spindle assembly of claim 5 further including a controller to monitor and control expansion of the bladder assemblies.
9. A tube expander spindle assembly, comprising:
 - a plurality of bladder assemblies, each bladder assembly including a probe assembly and an expandable bladder,
 - each probe assembly comprising a first member and a second member,
 - each member having an aperture axially extending the length of the member,
 - the first member further including a body with an axially extending shaft, the shaft having a cylindrical portion for receiving

the bladder with a first means for attachment at an end opposite the body, the body further having a second means for attachment opposite the shaft threads, the shaft having a second aperture extending between an outer surface of the aperture and the axial aperture,

the second member including a first end and a second end, the first end including a third means for attachment to mate with the first means for attachment of the first member in order to secure the first member and second member together, the second end including a fourth means of attachment;

a first connection tube of preselected length having a first end and a second end, with a hard stop mounted to the first end to control the length of the first connection tube from a preselected reference surface and means for attaching at the second end for removably attaching the connection tube to one of the members of the probe assembly, the connection tube further including an axially extending aperture;

a plurality of additional connection tubes of preselected length, each tube having a first end and a second end, with a means for attaching at each end for attaching the end of the connection tube to one of the members of the probe assembly, each of the plurality of the connection tubes further including an axially extending aperture;

means for fluidly sealing the means for attaching the connection tubes to the bladder assemblies;

wherein the axially extending apertures of the connection tubes are in fluid communication with the apertures in the bladder assemblies when assembled to bladder assemblies to form a tube expander assembly spindle;

a means for sealing the apertures located at an opposite end of the tube expander assembly spindle from the first connection tube; and

means for pressurizing the tube expander assembly spindle, the means for pressurizing in fluid communication with the apertures in the bladder assemblies and the connection tubes.

10. The apparatus of claim 9 further including a controller to monitor and control the pressurization of the bladder assemblies.

11. The apparatus of claim 9 wherein the means for pressurizing the fluid includes a hydraulic pump and a hydraulic fluid.

12. The apparatus of claim 12 wherein the hydraulic fluid is a hydraulic oil.

13. The apparatus of claim 12 wherein the hydraulic fluid is water.

14. A tube expander assembly, comprising:

a plurality of bladder assemblies, each bladder assembly including a probe assembly and an expandable bladder,

each probe assembly comprising a first member and a second member,

each member having an aperture axially extending the length of the member,

the first member further including a body with an axially extending shaft, the shaft having a cylindrical portion for receiving the bladder with a first means for attachment at an end opposite the body, the body further having a second means for attachment opposite the shaft threads,

the second member including a first end and a second end, the first end including a third means for attachment to mate with the first means for attachment of the first member in order to secure the first member and second member together, the bladder being mounted over the first end of the second member and the

cylindrical portion of the shaft of the first end, the second end further including a fourth means of attachment,

wherein the probe assembly includes a substantially radially extending aperture in fluid communication with one of the axial apertures extending through the first and second members;

a first connection tube of preselected length having a first end and a second end, and means for attaching at the second end for removably attaching the first connection tube to one of the members of the probe assembly, the connection tube further including an axially extending aperture;

a plurality of additional connection tubes of preselected length, each tube having a first end and a second end, with a means for attaching at each end for attaching the end of the connection tube to one of the members of the probe assembly, each of the plurality of the connection tubes further including an axially extending aperture;

means for fluidly sealing the means for attaching the connection tubes to the bladder assemblies;

wherein the axially extending apertures of the connection tubes are in fluid communication with the apertures in the bladder assemblies when assembled to bladder assemblies to form a tube expander assembly spindle;

a means for sealing the apertures located at an opposite end of the tube expander assembly spindle from the first connection tube;

a means for locating the tube expander assembly within a tube relative to a datum so that each bladder in the plurality of bladder assemblies is located at a preselected position along the tube; and

means for pressurizing the tube expander assembly spindle, the means for pressurizing in fluid communication with the apertures in the bladder assemblies and the connection tubes.

15. The tube expander assembly of claim 14 wherein the datum is a reference feature of a chiller.
16. The tube expander assembly of claim 15 wherein the reference feature of the chiller is a tube sheet within the chiller.
17. The tube expander assembly of claim 15 wherein the preselected position of each bladder in the plurality of bladder assemblies along the tube is adjacent to a tube support so that application of pressure by the means for pressurizing the fluid causes each bladder to expand against the tube and to deform against the tube support.
18. The tube expander assembly of claim 17 further includes the preselected position of the bladder in a bladder assembly at an end of the tube expander assembly is adjacent a tube sheet.
19. The tube expander assembly of claim 16 wherein the means for locating the tube expander assembly within a tube includes a hard stop associated with the first connection tube.
20. The tube expander assembly of claim 19 wherein the hard stop is integral with the first connection tube.
21. The tube expander assembly of claim 19 wherein the hard stop is attached to the first connection tube.
22. The tube expander assembly of claim 19 wherein the hard stop includes a means to adjust the axial length of the first connection tube, thereby adjusting the length of the tube expander assembly.

23. The hard stop of claim 22 further including a counterbore to accept a tube protruding from the tube sheet, so that the hard stop can contact the tube sheet.

24. A method for expanding a tube in a chiller against a plurality of tube supports comprising the steps of:

assembling a tube into a chiller by inserting the tube through at least one tube sheet and a plurality of tube supports;

providing a tube expander assembly, the tube expander assembly comprising

a plurality of bladder assemblies, each bladder assembly having an axial first end and an axial second end, each end having a means for attachment, and an expandable bladder positioned between the first end and the second end in fluid communication with the first end and second end;

a first connection tube of preselected length having a first end and a second end, with a means for locating the first connector tube relative to a datum mounted to the first end, and means for attachment at the second end for removably attaching the first connection tube to an axial end of one of the bladder assemblies, the connection tube further including an axially extending aperture in fluid communication with the bladder assembly;

a plurality of additional connection tubes of preselected length, each tube having a two axially-opposed end, with a means for connection at each end for attaching one end of the connection tube to an axial end of one of the bladder assemblies of the plurality of bladder assemblies and the remaining end to an axial end of another of the bladder assemblies of the plurality of bladder assemblies, each of the plurality of the connection tubes further including an axially extending aperture to provide fluid communication between the attached the bladder assemblies; and

means for fluidly sealing a second end of the last bladder of the plurality of bladder assemblies;

assembling the tube expander assembly into the tube so that each bladder in the plurality of bladder assemblies is positioned within the tube adjacent one tube support of the plurality of tube supports, each bladder corresponding to each tube support;

applying pressure to the tube expander assembly so that each bladder in the plurality of bladder assemblies simultaneously expands against the tube with sufficient pressure to plastically deform the tube against the tube supports;

holding the pressure for a preselected period of time; and
then releasing the pressure.